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AUTHOR Bohr, Louise
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ABSTRACT

This study considers the effects of course types on reading, mathematics, and critical thinking skill gains for college freshmen. Course groups, arranged hierarchically in three tiers from large groupings down to individual courses, are used as units for analysis. Both Hard Applied and Hard Pure Biglan-paradigm course groups contributed to progress in mathematics, whereas no effects are revealed at the large grouping level for reading or critical thinking. At the second tier, applied science courses and pure humanities courses contributed to reading gain, applied science and pure math and science courses contributed to math gain, and the soft social science courses contributed a significant but negative effect on critical thinking gain. Individual course effects are also reported. The appendix provides responses to a follow-up survey question asking students to indicate their freshman year course taking patterns. Contains 13 references. (Author/GLR)

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# Effects of Course Type on Freshman Learning*

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Louise Bohr
College of Education (M/C 147)
University of Illinois at Chicago
Box 4348
Chicago, Illinois 60680

HE 026 449

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## Abstract

This study considers the effects of course types on reading, mathematics and critical thinking skill gains for college freshmen. Course groups, arranged hierarchically in three tiers from large groupings down to individual courses, are used as units for analysis. Both Hard Applied and Hard Pure Biglan-paradigm course groups contributed to progress in mathematics, whereas no effects were revealed at the large grouping level for reading or critical thinking. At the second tier, applied science courses and pure humanities courses contributed to reading gain, applied science and pure math and science courses contributed to math progress, and the soft social science courses contributed a significant but negative effect on critical thinking gain. Individual course effects are also reported.

One efficient way to insure the provision of efficient college courses is to study extant courses to find those which best promote academic learning. Much descriptive inquiry has been devoted to describing this progress in skills for college students (Beeken,1982; Blackburn et al, 1976; Cohen, 1986; Coleman, 1960; ETS, 1954; Learned and Wood, 1938; Palmer, 1984; Prather, 1976; Warren, 1975). However, fewer studies have sought to find the more precise relationship of the labyrinth of courses taken to the student's actual learning (Ratcliff & Associates, 1988). The problem of teasing out effects of learning from student course taking patterns is complex; course effects should not be considered individually, since most students proceed through constellations of courses each year. While students may increase academic ability through only one course, or through two in tandem, it may be that students require particular groupings of courses to receive the full academic environment needed for learning. Any consideration of course effects must be done in recognition of cumulative effects.

Another problem facing this type of investigation has been the absence of clear measures, during the events in college, of progress in academic learning. Researchers have often lacked appropriate measures of college learning, both created to measure yearly college learning in academic areas, and executed during the progress of course involvement. College and graduate entrance exams may be either chronologically distant or imprecise measures for the many subject area accomplishments of the undergraduate.

Student transcripts have been analyzed to determine frequent constellations of courses through the use of cluster analysis (Ratcliff &

Associates, 1988). Common groupings of courses of all types may then be compared to each other for effectiveness in various learning areas. This unit of analysis is holistic in approach, as it approximates a full picture, or academic major effect. Yet each student moves through the curriculum in a unique fashion; and the possibility exists that no "typical" or "classical" course taking pattern occurs at a frequency which allows characterization.

An alternative to this method is the grouping of courses according to similarity in subject matter. Effects of similar subject courses in "blocks" may then be observed in their effectiveness in the promotion of learning in different skill areas. With course groups as a unit of analysis, the nature of learning across a student population may be observed as an effect of *course type*. For example, the effects of courses in all sciences on the learning of math or reading may be considered. Or, the effects of a particular type of science course on critical thinking, for example, an applied science such as engineering or pharmacology, may be considered.

Any grouping of courses for the investigation of learning effects should employ a parsimonious, topic-sensitive classification which reflects basic differences among courses available to freshman college students. An ideal choice for course classification is Biglan's (1973) inclusive and systematic division of disciplinary fields, validated and employed over the last two decades in a number of investigations. This division of disciplinary fields has consistently located the lines of separation among fields of college study for a variety of purposes.

A challenge to the discovery of effects with this type of grouping is the determination of an appropriate sized group of college

courses. If too many courses and course types are included, negative and positive effects may cancel each other out. What might otherwise be a clear contribution may be obscured. Yet if courses are considered within the curriculum on a one by one basis, individual courses may appear to contribute when in reality they've only been taken along with courses which are the true contributors. In the process of looking for course type effects, too-large group sizes may mask effects, and too-small group sizes may create them.

The objective of this inquiry is create a perspective from which to view the effects of college courses on learning. This perspective will consider the effects of courses with similar subject matter across the freshman class. Course subject matter groups, arranged hierarchically, are used as units for analysis rather than individual student paths or "transcript" paths through the curriculum. In this way it will be possible to begin to view effects on learning as results of more than one course at a time, and to contribute to the knowledge of effects of broader constellations of courses in academic majors and at particular institutions.

## Data and Design

For the present study, courses are grouped in both large and medium-sized groups. First, large groupings are tested for effect, then medium-sized groups are evaluated. Where the medium-sized groups are shown to contribute significantly to academic learning, these groups are further broken down to the actual course level, to view effects at the smallest level. This three-tiered grouping allows for both an overview and a closer look at how courses affect learning when grouped by topic. The

larger grouping may catch cumulative effects which the smaller groupings may not. The more concise and small topic groupings may encapsulate effects which have been lost or canceled as effects are observed in larger conglomerations.

The first and most broad categorization of courses is a Biglan (1973) classification of subjects using subject dimensions of hard to soft paradigms, and pure to applied orientation. Fields are sorted according to the degree of conformity in disciplinary paradigm, and to the degree of commitment for practical application. The physical sciences, mathematics, and computer science, for example, all employ consistent disciplinary paradigms, where other fields (such as literature, history, psychology, or linguistics) may use many or less defined paradigms. Pharmacology and engineering are fields where practical application is central, while philosophy and the humanities do not emphasize application as much. Because each field has a "soft/hard" designation, and a "pure/applied" designation, all undergraduate fields of study fall into one of the following four categories: Hard Applied Courses, Hard Pure Courses, Soft Applied Courses, and Soft Pure Courses. This categorization creates four distinct, salient groups of forty-seven (see Appendix A) undergraduate courses possibilities.

The medium-sized grouping are topic subcategories of these four Biglan-paradigm groups. Hard Applied Courses include three general subject matter areas: science, math, and computer study. The Hard Pure Courses contain only math and science. Since the remedial math courses are believed to be of a nature separate from the college and advanced and courses, they are considered separately. Therefore, three hard pure topic

subcategories are considered: pure science courses, pure math courses, and remedial math. Soft Applied Courses include two topic subcategories: social science and the humanities. The Soft Pure Courses also contain the social sciences and the humanities; however, since again the remedial courses are different from college courses, remedial humanities are also considered separately. The soft pure topic subcategories are therefore: pure humanities, pure social sciences, and remedial reading/study skills courses.

For the purposes of this study, the affects of the four categories from the highest tier are considered first. Then the eleven categories of the second tier are examined. Where second tier group effects are significant at $p < .05$, groups are further reduced toward the examination of individual course effects. Due to the lack of constellation effects at this level, final tier findings should be considered in the context of higher tier findings. See Figure 1 for an overview of the grouping structure.

## Sample and Instruments

The individuals in this study were 210 incoming freshmen who were part of a pilot study for a large national longitudinal investigation of the factors that influence learning and cognitive development in college. (The study was sponsored by the National Center on Postsecondary Teaching, Learning and Assessment, which is funded by Grant: R117G10037 from the U.S. Department of Education.) These students began post-secondary study in the fall of 1991. The institutional setting was a public, four-year, urban, Research I university with a primarily commuter undergraduate student body. The students were recruited to the study by

mail, and from the population of students attending precollege orientation. They were informed that they would be participating in a longitudinal study and that they would receive a generous stipend for their participation.

An initial data collection was conducted in the fall of 1991. The data collection lasted approximately four hours and students were paid a stipend of $35. The data collected included Form 88B of the Collegiate Assessment of Academic Proficiency (CAAP). The CAAP was developed by the American College Testing Program to assess selected general education skills typically obtained by students in the first two years of college (ACT, 1990). The CAAP consists of five, 40 minute, multiple choice test modules, three of which (reading comprehension, mathematics and critical thinking) were the focus of this study.

The CAAP reading comprehension test includes 36 items that assess the reading comprehension skills of referring, reasoning, and generalizing. The test consists of four prose passages of about 900 words in length that are representative of the level and kinds of writing commonly encountered in college curricula. The passages were drawn from topics in fiction, the humanities, the social sciences, and the natural sciences. The average KR-20 internal consistency reliabilities for the reading comprehension test range between .84 and .86. The mathematics test consists of 35 items designed to measure a student's ability to solve mathematical problems encountered in many postsecondary curricula. The emphasis is on quantitative reasoning rather than formula memorization. The content areas tested include pre-elementary, intermediate, and advanced algebra, coordinate geometry, trigonometry, and introductory



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calculus. The KR-20 reliability coefficients for the mathematics test ranged between .79 and .81. The critical thinking test is a 32 item instrument that measures the ability to clarify, analyze, evaluate and extend arguments. The test consists of four passages that are representative of the kinds of issues commonly encountered in a postsecondary curriculum. A passage typically presents a series of subarguments that support a more general conclusion. Each passage presents one or more arguments and uses a variety of formats, including case studies, debates, dialogues, overlapping positions, statistical arguments, experimental results or editorials. Each passage is accompanied by a set of multiple choice items. The KR-20 reliability coefficients for the critical thinking test ranged from .81 to .82 (ACT, 1990, pp 11-13, 33).

A follow-up testing of the sample took place in the spring of 1992. This data collection required about 3 1/2 hours and included Form 88A of the CAAP reading comprehension, mathematics and critical thinking modules. Students were paid a second $35 stipend for their participation in the follow-up testing. The National Center for Postsecondary Teaching, Learning, and Assessment Follow-up Survey was also completed during follow-up testing. In it, students were asked to indicate by circling a number from zero to five how many of each kind of college courses had been taken. Forty-seven course possibilities were presented within the survey, such that students indicated the number of courses he or she had taken. Exact courses and survey questions are reproduced in Appendix A.

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## Analysis

At each level, multiple linear regression is utilized in the estimation of course group effects on learning. In three separate analyses, each of the end-of-freshman-year CAAP ( reading, math and critical thinking) are regressed on groups of courses and individual courses. To correct for learning effects which may be a result of student precollege ability in each of the three areas, the fall pretest scores are used as covariates. A course group or individual course was entered after the covariate in order to determine this impact. Multiple regression is used in order to both evaluate and compare the contributions of various course types to the freshmen year increase in skills.

## Results

Resulting beta weights for Reading, Mathematics and Critical Thinking are reported in Tables 1 to 3.

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Insert Tables 1, 2, and 3 about here.

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**Reading** None of the Biglan-paradigm categories were found to contribute significantly to an increase in freshman reading scores,



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suggesting that these groupings are too coarse and mask more subtle effects on reading skills. However, within the second tier, both the applied sciences and the pure humanities have a significant contribution. While it may be expected that courses within the Humanities (English Literature, The Classics, Philosophy) are intended to provided support for reading technique and to improve literacy skills for freshmen, it is surprising that applied science courses behave similarly. In addition, courses which have been created specifically to increase reading skills – remedial academic and literacy skills courses -- do not have a significant effect. Perhaps the two second-tier groups--humanities and applied science courses--require more reading than other subcategories of courses, and it may be that reading practice, not instruction in reading itself, better promotes an increase in freshman reading scores.

Because both the humanities and applied sciences have been shown to contribute significantly in reading, further analysis was executed at the individual course level. In the applied sciences, engineering courses seem to have had the effect produced in this "layer". This effect is marginal, however, and individual course contributors remain somewhat unclear.

Within the humanities English literature, not surprisingly, accounts for the most variance. Writing courses appear to contribute ($p < .1$). Yet the impact on reading of these numerous and varied humanities courses deserve further examination because the humanities group includes such varied curriculum topics.

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**Math** Unlike Biglan-category effects for reading and for creative thinking, effects at the four-category tier for math were strong. All "hard" categories (Hard Applied and Hard Pure Courses) contributed significantly to the learning of math. Within the second tier contributors these "hard" course types may be identified: pure and applied science courses, and pure math courses. Again, though remedial courses are intended specifically to increase math skills, their effect is neither positive nor significant. This is probably not a function of the level of questions on the CAAP; the CAAP measure includes questions at remedial levels. Of the three course groups on the second tier, pure math courses contributed most, followed by pure science, and then by applied science courses.

Since three "hard" paradigm course types at the second grouping tier were shown to make significant contributions, each was examined in depth. Engineering has apparently contributed not only to reading improvement, but to gains in math skills. Chemistry may have a marginal effect. Among the pure math courses, calculus courses are the better provider of math skills. The CAAP mathematics test used includes measures of pre-elementary through advanced algebra, calculus and geometry. Nevertheless, the contribution of geometry classes was not large.

**Critical Thinking** None of the four category level groups produced significant effects, yet one course group engendered negative effects at the second level: soft pure social sciences. What is surprising is not which subgroup has the least positive contribution to advance in critical thinking, but the negative direction of the effect of the pure social sciences. One might expect expertise in argument and subarguments,

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especially experimental and statistical argument, to better develop in hard, not soft, disciplinary fields. No positive effect on critical thinking is documented from Hard Applied or Hard Pure Courses, only a negative effect from the pure social sciences. In fact, most pure social sciences at the freshman level show negative effects, and for history courses, this effect is significant.

## Conclusions

In summary, no effects were documented for reading or critical thinking when Biglan-paradigm course groups were examined for effect, whereas both Hard Applied and Hard Pure paradigm groups contributed to progress in mathematics. At the second tier, applied science courses and pure humanities courses contribute to reading gain, applied science and pure math and science courses contribute to math progress, and the soft social science courses may detract from critical thinking gain. At the level of individual courses, English literature shows a clear relationship to reading gain, while composition and engineering courses show a marginal effect. Both engineering and calculus show clear relationships to math gain, where geometry and chemistry may also contribute. History courses may be associated with a lack of progress in critical thinking.

The negative effects revealed in relation to the pure social sciences may only be an indication that students who concentrate on pure social science courses (especially those without the scientific paradigm tested on the CAAP critical thinking measures) are learning skills apart from logical argument. Students who work toward completion of non-



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scientific major core courses may, indeed, develop different skills during this period.

All findings should be interpreted cautiously, since the possibility exists that effects are influenced by the number of courses taken. If no students or few students happened to take a course, no effect will be evidenced. Students may have been making gains in courses which were taken due to curricular or scheduling constraints. Perhaps unpopular or rarely pursued courses would have had potent impacts. Since contributions to learning were based on the number of courses taken in a particular course area, courses which were easily accessed by students or prescribed more often by advisors are likely to appear more effective. This may account for weak effects of remedial courses, which are often taken by fewer students and are taken less frequently.

Some cognitive skill areas appear to be more easily influenced by course work. In mathematics, more course groups at each level affected score gains, and score gains were of a greater magnitude. Students with greater math ability may have had prerequisites for more math course options. With the addition of course effects in the second equations, the initial mathematics pretest variation explained was reduced; indicating that part of this variation may only have indicated the number of courses a student would take during the freshman year.

In contrast to math gains, reading and critical thinking gains were less prominent. This trend may simply reflect the fact that while courses are specifically offered in math topics, courses entitled "*Critical Thinking 101*" are rarely part of a college curriculum, and *reading* is



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never a subject matter in itself except as a remedial offering. The latter two skills are considered the by-products, not the subjects, of a college curriculum.

In addition, reading and critical thinking skills may be less finite; they may be more difficult to convey in courses. Perhaps significant math gains are made upon the learning and practice of a particular and finite set of formulas and procedures, and with the use of a limited number of numerical tools. Critical reasoning, which involves the application of procedures in an infinite number of unrelated circumstances, and which is applied differently in each case, may require the length of several college years to develop. Reading gains, which involve increased vocabulary and cultural literacy, require knowledge and skill acquisition in the expansive, non-finite arenas of world culture and the English lexicon.

Not only are some cognitive skills more conducive to gain, but some course types appear to be more conducive to the production of cognitive skills. As surprising as the weak effect of remedial courses is the strength of effects from pure and from applied science courses: in the latter case, especially engineering. Though neither course type above is intended as a course in math or literacy, both course types contribute to these skills. The salient element may be "rigor," or course level of difficulty. Perhaps the pure and applied sciences require extensive out-of-class work and demand a high level of student engagement in skill development. Effects would therefore be better related to course difficulty than course quantity.

It is suggested that, in further study, the pure humanities course grouping be further subdivided. Courses in such areas as dance, religious studies, music performance and foreign language are probably too disparate in topic to be considered in one grouping. In addition, since literacy development is different for speakers of English as a second language, some statistical control for first language might be explored. As has been suggested, procedures to document not simple course grouping effects, but course constellation contributions should be used to supplement this exploration to account for course combinations and their effects on cognitive skill increase.

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Appendix A

The NCTLA follow-up survey requests students indicate their freshman year course taking patterns . Five of the survey's questions are worded in the following manner:

*12. Please indicate the number of college courses you have taken in each of the following natural sciences or engineering fields by circling the appropriate number after each course category:*

*(Please circle only one number in each row.)*

| | | | | | | |
|---|---|---|---|---|---|---|
| *Astronomy* | *0* | *1* | *2* | *3* | *4* | *5* |
| *Biology* | *0* | *1* | *2* | *3* | *4* | *5* |
| *Botany* | *0* | *1* | *2* | *3* | *4* | *5* |
| *Chemistry* | *0* | *1* | *2* | *3* | *4* | *5* |
| *Engineering* | *0* | *1* | *2* | *3* | *4* | *5* |

Courses listed in this type of question include, in addition to those listed above:

Geology, Microbiology, Physics, Zoology, Pre-Algebra, Algebra, Calculus, Statistics, Computer Science, Geometry, Matrix Algebra, Accounting, Business Math, Anthropology, Audiology/Speech Pathology, Child and Family Studies, Communications, Economics, Geography, History, Political Science, Psychology, Sociology, Social Work, Drawing, Drafting, Architectural Design, Criminology, Education, Study Skills, Agriculture, Business, Physical Therapy, Pharmacy, Physical Education, Nursing, Computer Programing, Art History, Art Appreciation, Studio Art, Dance, Theater, Music Appreciation, Music Performance, Composition or Writing, English Literature, Foreign Language Humanities, Philosophy, Linguistics, Classics, and Religious Studies.

Note: The following courses were taken by no students in this freshman sample:

Zoology, Child and Family Studies, Architectural Design, Physical Therapy, Agriculture, Applied Art, Social Work.

| Table 1: Large Groups: Biglan Category Effects | | | |
|---|---|---|---|
| Independent Variables | Reading | Mathematics | Critical Thinking |
| Fall Pretest | .7611*** | .5999*** | .6422*** |
| Hard Applied Courses | .0460 | .1116* | .0180 |
| Hard Pure Courses | .0680 | .2323*** | .0822 |
| Soft Applied Courses | -.0048 | -.0021 | -.0280 |
| Soft Pure Courses | .0570 | .0424 | -.0347 |
| * p < .05, ** p < .01, *** p < .001 | | | |

| Table 2: Second Level Effects | | | |
|---|---|---|---|
| Independent Variables | Reading | Mathematics | Critical Thinking |
| Fall Pretest | .7236*** | .5162*** | .6067*** |
| Hard Applied Courses: | | | |
| Science | .0964* | .1009* | .0233 |
| Computers | -.0103 | -.0235 | .0645 |
| Math | .0533 | .0756 | -.0219 |
| Hard Pure Courses: | | | |
| Science | .0062 | .1424** | .0095 |
| Math | .0304 | .2067** | .0235 |
| Remedial: Math | -.0622 | -.0822 | -.0989 |
| Soft Applied Courses: | | | |
| Social Sciences | -.0511 | .0662 | -.0071 |
| Humanities | .0601 | -.0450 | -.0184 |
| Soft Pure Courses: | | | |
| Social Sciences | -.0592 | .0078 | -.1288* |
| Humanities | .1578*** | .0449 | .0938 |
| Remedial: Study Skills | -.0148 | -.0642 | -.0253 |
| *p < .05, **p < .01, ***p < .001 | | | |

Table 3: Course Level Effects for Reading, Mathematics and Critical Thinking

| Reading | | Mathematics | | Critical Thinking | |
|---|---|---|---|---|---|
| Hard Applied: Science | | Hard Applied: Science | | Soft Pure:: Social Sciences | |
| Fall Pretest | .7671*** | Fall Pretest | .6958*** | Fall Pretest | .6545*** |
| Nursing | .0000 | Nursing | .0208 | Economics | -.0926 |
| Pharmacy | -.0051 | Pharmacy | .0107 | Geography | -.0559 |
| Drafting | .0409 | Drafting | -.0156 | Psychology | -.0092 |
| Engineering | .0814 p < .1 | Engineering | .1318* | Anthropology | .0365 |
| Soft Pure: Humanities | | Hard Pure: Science | | History | -.1181* |
| Fall Pretest | .7440*** | Fall Pretest | .6923*** | Sociology | .0110 |
| Composition | .0908 p < .1 | Geology | -.0494 | Political Science | -.0344 |
| Music Appreciation | .0348 | Astronomy | -.0065 | | |
| Dance | -.0500 | Botany | .0645 | | |
| Classics | .0122 | Microbiology | .0101 | | |
| Religion | -.0093 | Biology | .0575 | | |
| Studio Art | .0522 | Chemistry | .1002 p < .1 | | |
| Music Performance | .0628 | Physics | .0342 | | |
| Theater | .0195 | Hard Pure: Math | | | |
| Philosophy | -.0228 | Fall Pretest | .5626*** | | |
| Humanities | -.0481 | Geometry | .1184 p < .1 | | |
| Linguistics | .0203 | Calculus | .2977*** | | |
| Foreign Languages | .0801 | Matrix Algebra | -.0869 | | |
| Drawing | .0092 | | | | |
| English Literature | .1399** | | | | |
| Art History | .0264 | | | | |

* p < .05, ** p < .01, *** p < .001

Figure 1. Overview of Course Grouping Structure

| Large Groups | Medium Groups | Individual Courses |
|---|---|---|
| Hard Applied Courses | Science | Nursing, Pharmacy, Drafting, Engineering, Architectural Design, Agriculture, Physical Therapy |
| | Computers | Computer Science, Computer Programming |
| | Math | Statistics, Accounting, Business Math |
| Hard Pure Courses | Science | Geology, Astronomy, Botany, Microbiology, Biology, Chemistry, Physics, Zoology, |
| | Math | Geometry, Calculus, Matrix Algebra |
| | Remedial Math | Pre-Algebra, Algebra |
| Soft Applied Courses | Social Sciences | Audiology/Speech Pathology, Criminology, Business, Education, Social Work, Child and Family Studies |
| | Humanities | Communications |
| Soft Pure Courses | Social Sciences | Anthropology, Economics, Geography, History, Political Science, Psychology, Sociology |
| | Humanities | Drawing, Art History, Applied Art, Studio Art, Dance, Theatre, Music Appreciation, Music Performance, Composition or Writing, English Literature, Foreign Language, Humanities, Philosophy, Linguistics, Classics, Religious Studies |
| | Remedial: Study Skills | Study Skills |

Note: These courses were taken by no students in this freshman sample: Zoology, Child and Family Studies, Architectural Design, Physical Therapy, Agriculture, Applied Art, Social Work.